

Chemical Oxidation Enhancing Organic Contaminant Remediation via the use of co-solvent surfactants

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Presentation Agenda

- Chemical Oxidation Technology Review and Limitations
- Enhancing Option to Chemical Oxidation using Cosolvent-Surfactant
- Case Study Presentation



Chemical Oxidation – Technology Review

- Oxidants are introduced or mixed into the soil and groundwater to attack the organic contaminants
- Chemical oxidation treatments are commonly used in potable and wastewater applications
- Oxidants are non-specific and will react with the targeted contaminants AND with the soil organic content.
- Chemical oxidation reactions involve the transfer of electrons and the breaking of chemical bonds
- Water is the carrier for the oxidants used in chemical oxidation (except for ozone)



Common Chemical Oxidants

- Potassium or sodium permanganate
- Hydrogen Peroxide alone
- Catalyzed Hydrogen Peroxide
 - > Hydrogen Peroxide with iron (regular Fenton reagent reaction)
 - Need to establish acidic conditions (ideal pH between 4 and 6)
 - Modified Fenton Reagent with chelated species (neutral pH)
- > Ozone
 - > Ozone is a gas and must be produced on site
 - > The gas must be injected into the soil
- Persulfate
 - > Requires activation to generate free sulphate radicals.
 - Heat, chelated metal, high pH or hydrogen peroxide can be used to activate the persulphate. Activation method can be adapted to site conditions.
- Percarbonate
 - Requires activation to generate free radicals



Chemical Oxidation – Limitations

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- All chemical oxidation reactions occur in the WATER phase (except for ozone)
- Kinetics of the chemical oxidation reaction is thus influence by the contaminant of concern solubility and availability in the groundwater
- Sorbed phase contamination might be challenging to remediate
- In NAPL containing sites, contamination can persist because of the highly hydrophobic properties of the chemicals that make up the NAPLs
- > Aqueous solubility's of many NAPLs are quite low for example:
 - Benzene ~ 1,791 mg/L
 - 1,1,1-trichloroethane \sim 1,495 mg/L
 - Tetrachloroethene \sim 150 mg/L
 - Naphthalene ~ 31.7 mg/L
 - 1,3,5-trichlorobenzene 6.01 mg/l
 - Benzo[*a*]pyrene ~ 0.003

Note: NAPLs that are made up of many non polar organic compounds have even a lower aqueous solubility.



Enhancing Chemical Oxidation using Cosolvent-Surfactant

- Surfactant are used by themselves to help increase the desorption rate of the contaminant of concern from the soil matrix
- Risk of mobilising of the contamination is present if surfactant application is not controlled properly especially if higher concentration of surfactant due to poor product distribution in the underground formation are formed.
- > Co solvent are used by themselves in soil washing application
- New approach target blends of BIODEGRADABLE co solvent AND SURFACTANT that DO NOT react with the oxidant and can be injected simultaneously together
- This influence the rate of partitioning of contaminants into the aqueous phase thus subsequent rate of the chemical oxidation reactions are increased
- Properties of the COSOLVENT-SURFACTANT blends to resist immediate chemical oxidation is key to simultaneously transport the surfactant and oxidants through the subsurface and target contaminated zones.
- Cosolvent-Surfactant are available for hydrogen peroxide, sodium persulphate and permanganate



Co solvent-Surfactant application example

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Co solvent-Surfactant application example



Time = 0 days



Co solvent-Surfactant application example

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Hexachloroethane (HCE), Octachlorostyrene (OCS), and Octachloronaphthalene (OCN).

Oxidant Dosage: 200 g/l of Sodium Persulphate with Alkaline Activation Source: Verutek Technologies



- Site type: Manufactured gas plant (MGP)
- ➢ Site Location: Long Island, New York in 2006
- Contaminant of concern: Coal tar DNAPL residually saturated soils with oil droplets
- ➢ Field trial test area: 30 ft by 60 ft and with a saturated thickness of approximately 60 feet.
- > Geology: medium to fine, well sorted sands.
- operating conditions are given in **Table 1**. Chemical injection took place at this site for 31 days on a 24 hour – 7 day per week basis.
- Groundwater monitoring to document the presence and persistence of the injected chemicals took place continuously at this site. Additionally, groundwater VOC and SVOC concentrations were measured on 5 occasions from 7 monitoring well clusters, including before and after treatment. Soil samples were taken from 54 discrete sampling locations before and after treatment..



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Table 1. Field Trial Test Operating Conditions

Test Conditions		Persulfate		CS blend		Fe(II)-EDTA		Liquid
		Average	Total	Estimated	Total	Average	Total	Total
	Duration	Conc.	Mass	Conc	Mass	Conc.	Mass	Volume
Phase	(days)	(g/L)	(k	(g/L)	(kg)	(mg/L)	(kg)	(gallons)
Start-up	2	13	2,600					26,250
Phase I	14	20	16,900	1	710	140	140	181,000
Phase Illa	7.6	44	18,400	2	850	290	120	112,400
Phase IIIb	8.3	45	37,400	2	1750	250	210	221,400
Totals	31.9		75,300		3,310		470	541,050

Notes: 1) Different persulfate concentrations used to evaluate density driven transport

2) Increase CS blend loading to evaluate dissolution

3) Two flowrates used: 10 gpm and 20 gpm (Phase IIIb only)



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Figure 7. MGP Field Trial Test Average Baseline Soil Concentrations by Depth





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Figure 8. MGP Pilot Test Average Post-Treatment Soil Concentrations by Depth





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> Figure 9. Soil Boring Photologs Comparing Preand Post-Treatment using the CS blend

One Hundred Year Old Tar Contaminated Soil @ 20 ft Below Ground Surface from a Manufactured Gas Plant Site





Co solvent-Surfactant Application Case Study Filed test results

- More than 4,000 kg of petroleum hydrocarbons were destroyed during the test. Following the completion of the pilot test in June
- Groundwater samples were taken quarterly from monitoring wells located up gradient and down gradient





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- Industrial and Municipal Waste Water
 - Contaminated Soil and Groundwater
 - Air, Odours and Atmospheric Emissions
 - Process Water

Products: coagulants, flocculants, nutrients, bacterial preparations strains, oxidants, catalysts, oxygen and hydrogen release compounds, odour control agents

Services: technical support, product selection, product supply and sourcing, logistics, laboratories (SOD and treatability testing), design and staff training.

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Thank you for your attention ! Have a good day !!!

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